Testing in Support of Space Radiation Shielding Composed of Nanocomposites

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Background

- For the particles composing space radiation, energy deposition is highly localized along the trajectory of each particle.
- Galactic Cosmic Ray (GCR) particles of average energy can penetrate a substantial thickness of materials, on the order of several inches of aluminum.
- If they suffer nuclear interactions, the lighter secondary products will lose energy at a lower rate, and therefore will be able to penetrate even further.

Shielding Considerations

- Except for physical properties and safety considerations, hydrogen would be the best shield.
- Polyethylene (PE), due to its high hydrogen content relative to its weight, has been shown to be an effective shielding material against galactic cosmic rays and solar energetic particles.
- The present work was funded to address the design, fabrication, and testing (including accelerator-based testing) of novel shielding materials that can be shown (i.e., via measured or simulated radiation transport properties) to approach or improve upon polyethylene's performance.

Objectives of the Project

- Synthesize multifunctional nanocomposities based on polyethylene with dispersed boron-rich nanophases.
- Experimentally test the radiation shielding properties of these composites and compare with polyethylene and aluminum.
- Evaluate the mechanical properties (especially impact and toughness).
  - Best candidate will also be evaluated for effectiveness as a flame retardant and ballistic/hypervelocity impact performance.

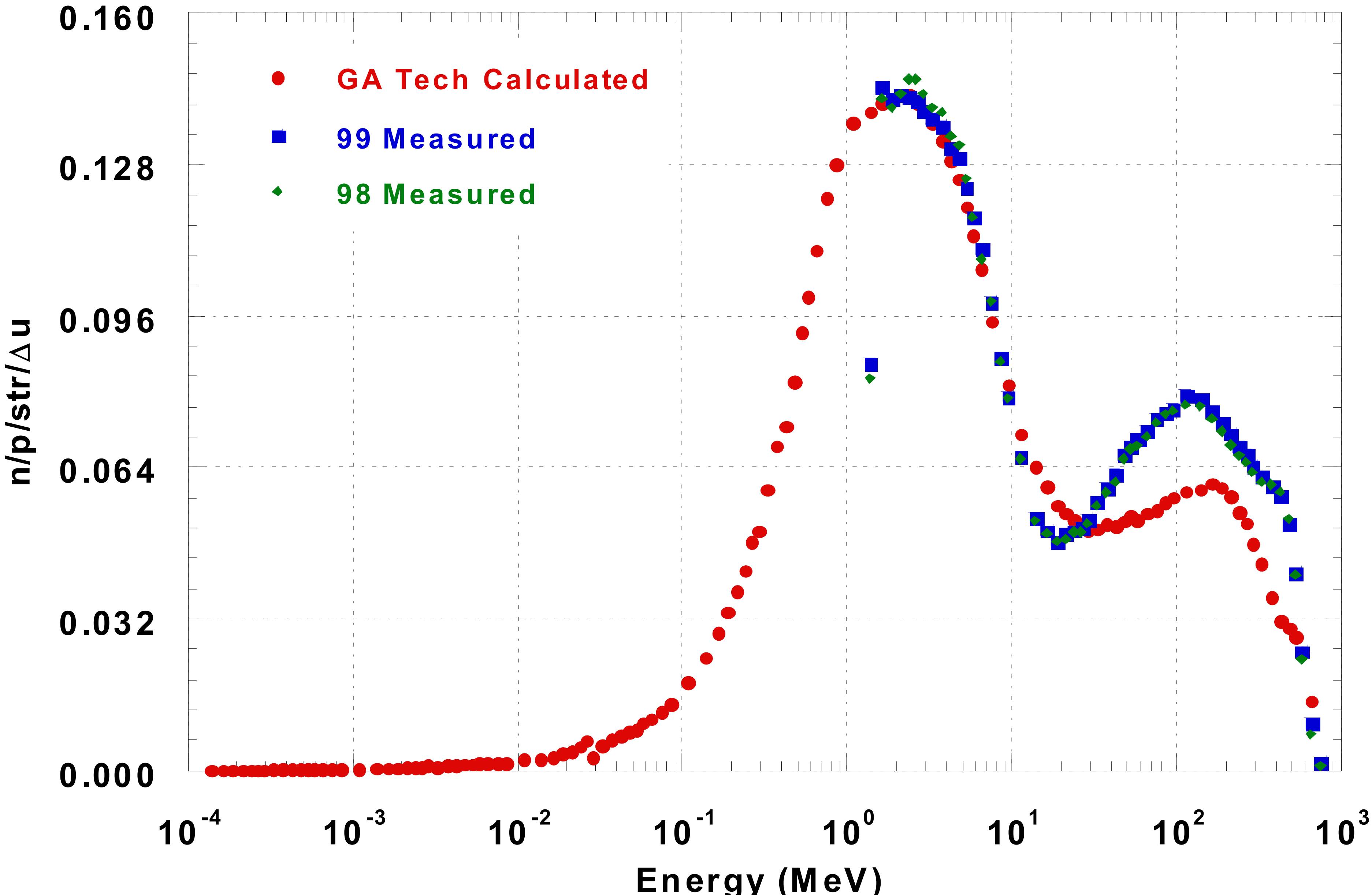
Radiation Shielding Tests of Material

- WNR Neutron Beam on 30L
- University of Maryland Research Reactor Thermal Column
- Fermilab Proton Beam
- Georgia Tech AmBe Neutron Source

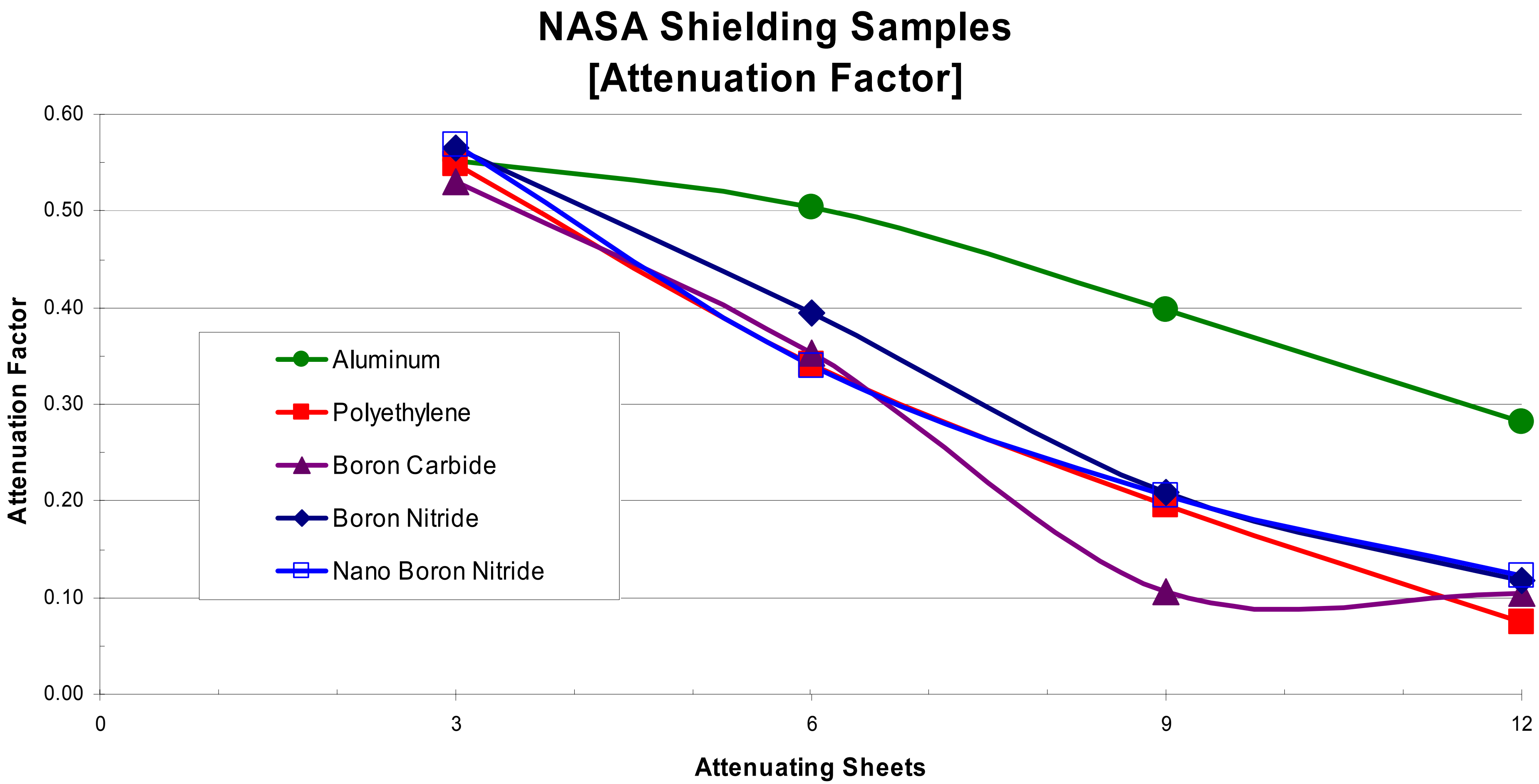
Materials

- Aluminum
- Polyethylene
- Polyethylene with Boron Nitride Nanoparticles
- Polyethylene with Boron Nitride
- Polyethylene with Boron Carbide

Neutron Beam WNR 4FP30L



Attenuation Curves from WNR

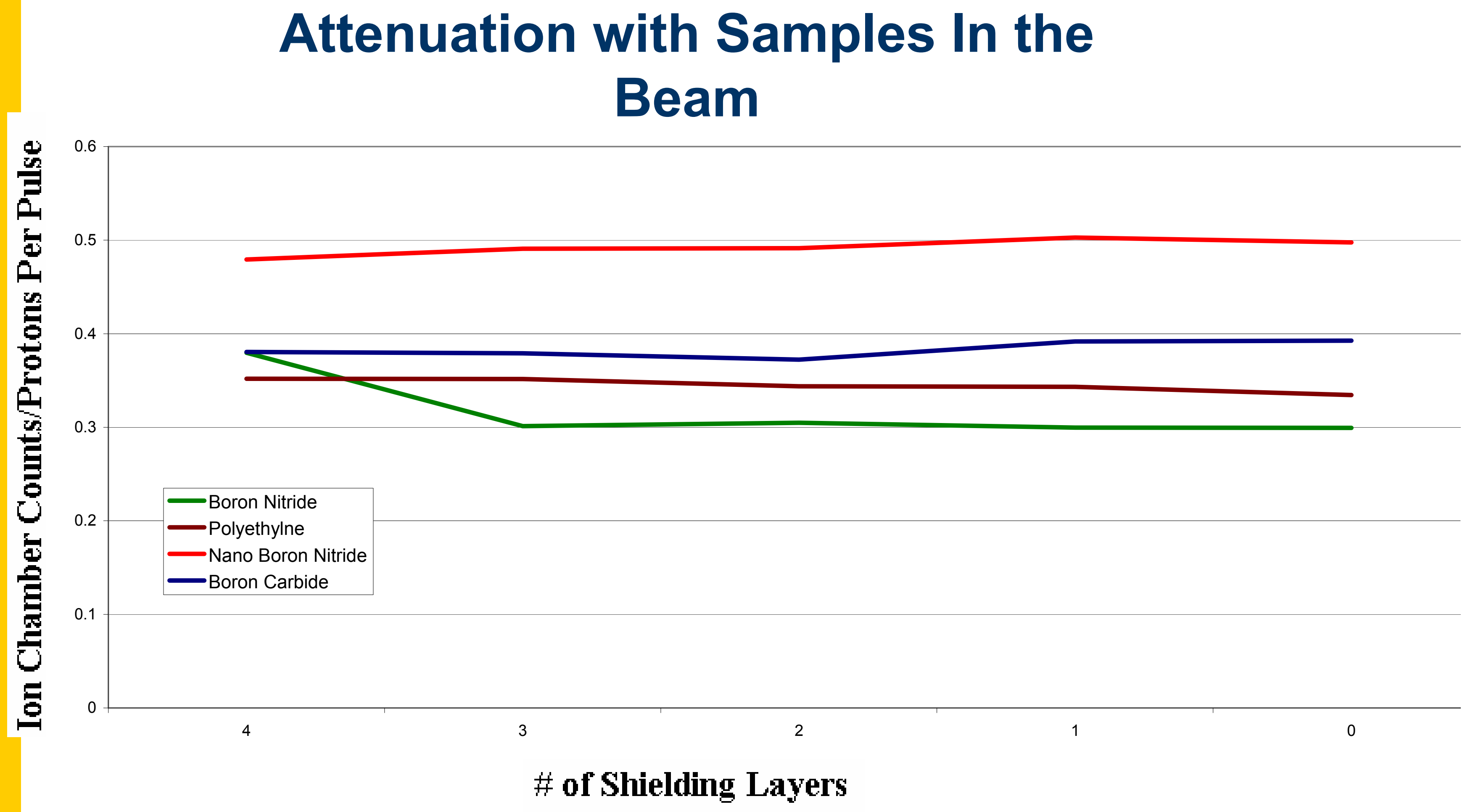


Fermilab Experimental Setup

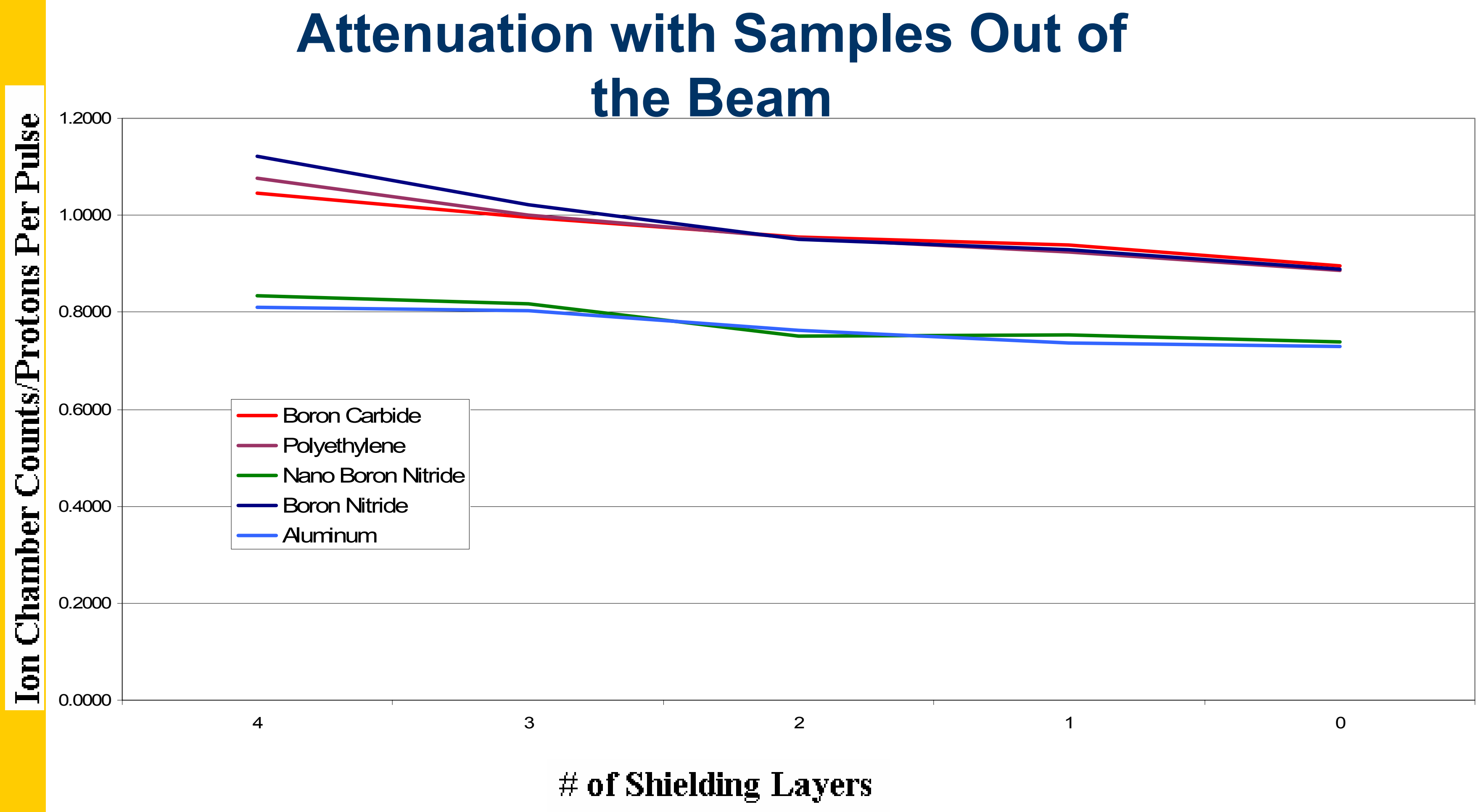
Attenuation Measurements

- Tissue-Equivalent Ion Chamber
  - 1 cm^3 gas volume
  - In center of 30 cm x 30 cm x 30 cm tank of water
- Charge Collected for 4 Different Thicknesses of Shielding Material
- Absorbed Dose Ratio Computed Using Charge Collected with no Shielding Material Interposed
- 120 GeV Proton Beam

Preliminary Results



Preliminary Results contd.



Acknowledgements

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Good beam comes from happy protons.

Happy protons come from Fermilab!